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Proposed Model Policies for Urban Drainage Management

Research Report No. 102

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Research Program for the Abatement of Municipal Pollution under Provisions of the Canada-Ontario Agreement on Great Lakes Water Quality

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These RESEARCH REPORTS describe the results of investigations funded under the Research Program for the Abatement of Municipal Pollution within the provisions of the Canada-Ontario Agreement on Great Lakes Water Quality. They provide a central source of information on the studies being carried out in this program through in-house projects by both Environment Canada and the Ontario Ministry of Environment, and contracts with municipalities, research institutions and industrial organizations.

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PROPOSED MODEL POLICIES FOR URBAN DRAINAGE MANAGEMENT

Report of the
Urban Drainage Policy Committee
to the
Urban Drainage Subcommittee

RESEARCH PROGRAM FOR THE ABATEMENT
OF MUNICIPAL POLLUTION WITHIN THE
PROVISIONS OF THE CANADA-ONTARIO
AGREEMENT ON GREAT LAKES WATER QUALITY

Project No. 77-1-47

This document may be obtained from -

Training and Technology Transfer
Division (Water)
Environmental Protection Service
Environment Canada
Ottawa, Ontario
K1A 1C8

Ontario Ministry of the Environment
Pollution Control Branch
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Toronto, Ontario
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17208

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Cat. No. En 43-11/102E
ISBN 0-662-11341-1
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FOREWORD

On August 13, 1971, the Government of Canada and the Government of the Province of Ontario signed an agreement (the Canada-Ontario Agreement on Great Lakes Water Quality) to ensure that the water quality of the Great Lakes is protected and enhanced. This agreement was consummated in response to the recommendations of the International Joint Commission (IJC) concerning pollution of the lower Great Lakes and in anticipation of the Canada-United States Agreement on Great Lakes Water Quality, which was signed on April 15, 1972, and subsequently revised and renewed in 1978.

The purpose of the Canada-Ontario Agreement (COA) was to permit Canada and Ontario to carry out their obligations under the International Agreement. The principal provisions under COA were for the acceleration of the construction of municipal sewage treatment projects, the upgrading of existing sewage treatment facilities (including introduction of phosphorus removal at all significant municipal sources), and the institution of a research program aimed at improving municipal pollution abatement operations at a lower cost than was possible using existing technology.

To oversee the administration and implementation of the various provisions of COA, a Review Board was established. To support the work of the Board in implementing the research program, a Technical Committee with four subcommittees was appointed. The Urban Drainage Subcommittee was formed specifically to coordinate research into urban drainage management.

Since the signing of COA, a substantial number of research studies have been carried out to determine the magnitude of pollution from urban drainage sources and to develop analytical and control techniques for these pollution sources. The studies indicated a cause for concern because urban runoff, and particularly combined sewer overflows, were found to be major sources of pollutant loadings to receiving waters. The studies also indicated that technology was available to aid in abating pollution from these sources. It became clear that pollution from urban drainage could not be controlled without considering flooding problems as well. Consequently, the Urban Drainage Subcommittee requested that an Urban Drainage Policy Committee be formed to consolidate all the research

and development findings and propose comprehensive model policies for urban drainage management that would lead to the alleviation of pollution as well as the resolution of flooding problems in urban areas. It was also requested that the proposed model policies take into account the administrative and legislative framework in Ontario. The model policies could then be considered for adoption by the Ontario Government. With minor but appropriate modifications, these model policies could also form the basis of urban drainage management programs in other jurisdictions.

With the submission of this document as the final report of the Urban Drainage Policy Committee, it must be stressed that this Committee was not specifically charged with developing official policies for Ontario. This must await the formation of an Ontario policy implementation committee, and an evaluation of the impact that the proposed model policies would have on the financial and human resources in Ontario if they were adopted by the province. Nevertheless, the Policy Committee considers the concepts outlined in this report suitable for incorporation into concrete policies that could prove both economic to implement and beneficial to the people of Ontario.

The members of the Policy Committee were:

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T.C. Clarke	Environment Canada
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T. Kurtz	Ministry of Natural Resources
F.I. Lorant	M.M. Dillon Limited (consultant under contract)
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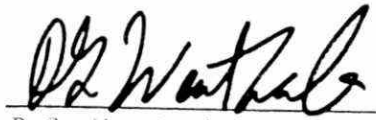
B.R. Ward	Ministry of Environment
D.G. Weatherbe	Ministry of Environment

The co-chairmen of the Urban Drainage Policy Committee would like to thank the Committee members and their affiliated agencies for their efforts and cooperation in the development of these model policies. Various other government and private organizations have made valuable comments to and carried out discussions with individual committee members on numerous occasions. Their substantial contributions towards the production of this document are gratefully acknowledged.

A draft of this report dated December 1978 was circulated for comments in 1979 to staff in the agencies represented on the Committee and also to the Urban Development Institute, the Housing and Urban Development Association of Canada, the Association of Planners of Ontario, the Consulting Engineers of Ontario, and all conservation authorities in Ontario. The reviewers comments were taken into consideration in revising the draft; however, this does not necessarily constitute endorsement of the final report by these agencies and groups.



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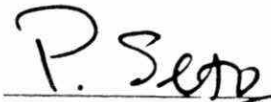

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SUMMARY

The Urban Drainage Policy Committee was formed in 1977 to propose model policies for control of flooding, pollution and erosion problems resulting from urban drainage. On the basis of studies carried out by the Urban Drainage Subcommittee of the Canada-Ontario Agreement on Great Lakes Water Quality, combined sewer discharges and storm drainage from urban areas had been recognized as significant sources of pollutants. The development of urban areas creates a potential for increased erosion of land and sedimentation in watercourses during and after construction. Urban areas include large impervious surfaces that result in increased volumes and rates of runoff, and storm drainage systems, which have been traditionally designed to remove the runoff as quickly as possible, accelerate flooding, erosion and sedimentation downstream in natural watercourses. Improper sewage system layout or design may cause frequent comined sewer overflows and treatment plant by-passes. Inadequate sewer facilities coupled with inappropriate drainage designs may cause on-site flooding and structural damage. Lack of coordination among government agencies concerned with drainage matters may, at times, result in incompatible drainage policies and guidelines, and lengthen administrative and approval procedures.

These drainage-related problems have been experienced to a certain extent in some of Ontario's developed or developing urban areas, mainly because most of the traditional approaches to urban drainage management are still being used. Continuing use of these approaches will intensify drainage problems and remedial measures will be costly.

The assessment of current practices in urban drainage planning and engineering demonstrates the need for a new and more comprehensive approach. Such a new approach consists of the application of new drainage concepts through a broader use of existing municipal planning mechanisms, using new and innovative technology where needed. The approach is described in five policy proposals:

1) Municipalities, in coordination with the conservation authorities, should develop master drainage plans for all watersheds within their boundaries. The purpose of this policy is to foster master

drainage planning in rapidly developing municipalities so that storm water drainage systems can be developed in a manner compatible with watershed needs, to identify existing water quality and flooding problems, and to avoid future problems.

2) Municipalities with sewage collection and treatment systems should formulate and implement a comprehensive pollution control strategy that considers both wet and dry weather pollution sources. In the initial stage of the formulation, an in-system review of previously unidentified wet weather sources, volumes and magnitudes of pollution should be carried out. Consideration of receiving water objectives, and the cost and effectiveness of wet weather versus dry weather controls would lead to a final comprehensive strategy. The end result would be more cost-effective investment in municipal pollution control.

3) Drainage systems for all new development should be designed using the major-minor concept, which recognizes the drainage system's dual role of providing convenience during minor (high frequency) runoff events and minimizing property damage and protecting life during major (rare) runoff events. Expenditures for sewer construction are expected to be reduced since the minor system would be designed to avoid excessive costs incurred by the use of overly conservative design techniques or excessively rare design runoff events, while the major system would be designed to provide protection against damage from runoff events that exceed the capacity of the minor system. The overall drainage system would also provide a higher level of protection since a major system of flow routes on roadways and drainage easements would be provided for rare events, and an awareness that some level of inconvenience would be experienced from time to time would be introduced.

4) Proponents of new urban developments should indicate the effects of the development on the watershed and carry out mitigative measures as required. Hydrologic changes and pollutional effects on the receiving watercourse are considered to be the important effects in this case.

5) Proponents of new urban developments should plan for and carry out an erosion and sediment control program in the planning and construction stages of development, and follow this with an adequate maintenance program. Construction-generated sediment pollution is considered a severe enough problem to justify controls on an across-the-board basis.

The acceptance and implementation of these proposals will ensure that drainage problems that occurred in the past will be minimized in the future and needless expenditures avoided. Safety would be improved and the environment enhanced, in most cases without increasing the total cost of the urban drainage system, and in some cases at lower cost. Furthermore, the implementation of these proposed policies would provide better coordination between the various government agencies involved and simplify urban drainage administrative and approval procedures.

Adequate planning procedures are currently available in Ontario for the adoption and implementation of these model policies, and legislation exists to support the policies. The technology necessary to implement these policies is also available. Computer model packages for the analysis of urban runoff systems and comparison of various drainage, storage and treatment alternatives are available. Various strategies for controlling runoff quantity and quality have been demonstrated. In fact, certain municipalities in Ontario are already using these analytical and control technologies to resolve drainage and pollution problems.

1 INTRODUCTION

The technical background for this report was provided by studies carried out under the Urban Drainage Subcommittee of the Technical Committee for the Canada-Ontario Agreement on Great Lakes Water Quality, and by studies conducted through the Pollution from Land Use Activities Reference Group (PLUARG) for the International Joint Commission.

This document is intended to:

- provide an overview of urban drainage management philosophy;
- demonstrate the need for and describe a new approach to urban drainage management;
- propose policies that incorporate the new approach;
- provide advice on the implementation of these policies.

1.1 Urban Drainage Subcommittee Studies

The Urban Drainage Subcommittee studies were carried out in three phases:

a) definition of the magnitude and significance of pollution problems due to urban runoff;
b) development or recommendation of appropriate analytical and control technology for resolving problems; and
c) development of a strategy for implementing solutions.

It was concluded from the first phase that urban runoff is a significant source of pollution, particularly in the case of combined sewer overflows. The significance of the pollution, and thus the need for control, depends on the cumulative effect on the Great Lakes and on the effect in the local receiving water. It became apparent that pollution control of urban runoff could not be considered without also considering flood control, since municipalities and property owners are most concerned with basement and surface flooding and both types of flooding occur relatively frequently. It also became clear that the effects of urbanization on the runoff hydrology could result in water quality degradation, flooding and channel erosion in the receiving watercourse.

The second phase of the UDS program led to the development of new technology for runoff control and the development of analytical tools for assessing control alternatives.

The third phase of the program, dealing with development of a strategy for implementing solutions, led to a series of conferences and publications with the goal of transferring the information and technology gained in the program to potential users - primarily municipalities and consulting engineers. This phase also included the development of the "Manual of Practice for Urban Drainage" (COA Research Report No. 104) and formation of the Urban Drainage Policy Committee. The manual provides an overview of urban drainage problems and solutions, and the technical background used by the Policy Committee.

One of the key findings of the UDS program was the general recognition by those involved in the planning of urban drainage systems of the need for a comprehensive, systematic and coordinated approach to urban drainage. Such an approach had to be applicable to both existing and new developments, and incorporate or link together existing policies of the various government agencies involved. A need for more expedient administrative procedures to minimize delays to development because of drainage-related considerations was also identified.

Policies, guidelines and procedures which encourage use of the best available design techniques, drainage practices and technology were considered essential to any new approach. A need was also recognized at all technical levels for better drainage planning, and for more thorough analysis in the design stage of new development of drainage considerations, such as pollutant loads, impacts on receiving waters, and flood or pollution control alternatives.

During the coming years large amounts of money will continue to be spent on urban drainage as part of the servicing of new development and for the correction of servicing problems in existing areas. Most of the money will ultimately have to be provided by the citizens of the province. Continuing and intensifying population growth in existing areas will add to the complexity of drainage systems and make wise allocation and sharing of public investment to solve drainage-related problems more difficult than at present.

The new approach must necessarily start with a common government philosophy towards urban drainage management and the associated environmental and land-use considerations. Recognition of this need led

to the formation of the Urban Drainage Policy Committee, and the preparation of this report.

1.2 PLUARG Studies

The Canada-U.S. Agreement on Great Lakes Water Quality of 1972 led to the study of pollution in the boundary waters of the Great Lakes system from land use activities. Past studies had indicated that current conditions in the lakes could not be related entirely to readily identifiable point sources. In order to quantify and describe non-point sources of pollution, PLUARG studied the pollution potential of several land use activities, including agricultural, urban, forestry, transportation and waste disposal activities, as well as natural processes such as lakeshore and river bank erosion. PLUARG also examined atmospheric deposition of material on land and water surfaces.

On a lake-wide basis the major problems were considered to be eutrophication or accelerated aging of the lakes, and the buildup of toxic substances in the lakes. The study found that the Great Lakes are being polluted by phosphorus, sediments, some industrial organic compounds, some previously used pesticides, mercury and, potentially, other heavy metals. Local problems in some near-shore areas are associated with sediments and microorganisms in land drainage. Combined sewer overflows were recognized to cause increased loadings of most pollutants and elevated microorganism levels in local receiving waters.

Recommendations in the PLUARG report to the IJC* included the development and implementation of management plans to reduce the loadings of phosphorus, sediments and toxic substances from rural and urban areas. It was recommended that the management plan for urban areas include:

i) proper design of urban storm water systems in developing areas such that natural stream flow characteristics are maintained;
ii) provisions for sediment control in developing areas; and
iii) control of toxic substances from commercial and industrial areas.

The IJC, on its report** on the PLUARG findings to the governments of the United States and Canada, stated:

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* Environmental Management Strategy for the Great Lakes System, International Joint Commission, Windsor, Ontario, 1978.

** Pollution in the Great Lakes Basin from Land Use Activities, International Joint Commission, Windsor, Ontario, 1980.

> "the major problems of urban non-point pollution, with the exception of combined sewer overflows, relate to the control of sediment and associated pollutants. To a large degree these problems can be prevented or alleviated by greater awareness, planning and proper design of urban developments and infrastructure. The preventative approach should be universally adopted for new urban development. Application of structural remedies to existing urban areas will be extensive and more difficult to achieve, and should be assessed on a case by case basis".

It is further suggested that the approach described above be adopted in addition to methods such as street sweeping for control of pollutants at source in developed areas.

2 PROBLEM DESCRIPTION

2.1 The Drainage Objective

The various levels of government have the common goals of preserving and improving the quality of the environment for present and future uses, protecting life and property from damages, conserving natural resources, and maintaining and upgrading the standard of living, as well as supporting orderly development. In terms of urban drainage management, these goals can be translated into the following specific objectives:

a) Prevent health hazards, loss of life and property damage on site.
b) Minimize inconvenience from surface ponding and flooding on-site.
c) Minimize alteration of the local groundwater system and the hydrology of receiving watercourses.
d) Minimize downstream flooding, changes in natural stream channel geometry and channel erosion.
e) Minimize pollution discharges to watercourses.
f) Minimize sediment pollution of watercourses from construction activity.
g) Minimize impairment of fisheries, fish habitat and other aquatic life.

In meeting these objectives, costs should be minimized. The rights of riparian owners also should be maintained, unless these rights have been specifically set aside by legislation.

2.2 General Effects of Urbanization

When urban areas are developed, provision is made for conveyance of storm runoff and sanitary wastes. Urban areas designed with "separated" sewerage have both sanitary networks and storm drainage networks. In rural and low-density residential areas, sanitary sewage may be disposed of through private septic tanks and tile drainage systems which produce no discharge to surface waters, if performing correctly.

The sanitary sewer network is intended to collect domestic and specific categories of polluted industrial wastewaters, and convey them to a sewage treatment facility. The sanitary system consists entirely of man-made elements, i.e., enclosed conduits of various kinds.

The storm drainage network is intended to collect surface runoff plus unpolluted water from industrial or commercial sources, then convey and discharge them to a watercourse. The storm drainage network can include both natural and man-made elements, i.e., open channels and enclosed conduits.

In the serviced area, the storm water drainage system, which includes drainage pipes, roadway gutters, enclosed conduits and roof leader connections, has been designed to carry runoff away swiftly, with inlets provided on street surfaces and private property. This provides maximum convenience during less intense storms. However, in general and until very recently, little consideration has been given to the flow and conveyance of the excess of water that accumulates during severe storms when the capacities of these conduits and gutters are exceeded. Flooding and property damage can result. Flooding and property damage to houses or structures in the serviced area can occur above-ground, or below-ground in basements. Structural damage or flooding of basements is often caused by surcharging of the storm sewer drainage connections that are usually provided on private property to carry away roof leader and weeping tile flows.

The rapid transfer of increased rates and volumes of runoff from urban development has increased the likelihood of drainage-related problems in receiving streams, i.e., flooding, bed and bank erosion, and sedimentation. The accelerated erosion, higher downstream flow-volumes and flood-peaks in wet weather inevitably require remedial measures such as diverting, widening, straightening, deepening or enclosing the stream. The increased imperviousness of the developed area and the swift conveyance of storm water away from the site also lead to a depletion of groundwater and consequent decreases in the baseline or dry weather flow in smaller receiving streams after urbanization.

Pollutants accumulated on the land during dry weather are washed readily from impervious surfaces into the storm sewers and to the receiving stream. Among the products conveyed to the receiving stream in runoff are suspended solids, heavy metals, fecal materials of animal origin, phosphorus, deicing salts, street litter and debris. These pollutants can contribute both shock loads and background pollution to

receiving waters. Beneficial water uses can be affected if the body of water receiving the runoff has inadequate assimilative capacity.

Swimming can be curtailed due to higher levels of pollution indicator and pathogenic bacteria. Aesthetic appearance can be degraded by turbidity and litter. Suspended and dissolved pollutants, and toxic chemicals in the runoff can seriously damage aquatic life because these materials can cause sedimentation in spawning beds and reduce dissolved oxygen concentrations in the receiving stream. The build-up of chemicals in the receivers and in fish tissue can pose a health hazard to man.

While runoff usually contains some suspended sediment entrained through the action of rainfall and water flowing over ground surfaces, the sediment loadings are much greater during the construction period when vegetation is removed and soil is exposed. Areas undergoing development can have a sediment yield of five to twenty times that of already developed areas. The detrimental effects of this increased sediment load include loss of valuable topsoil, increased turbidity, sedimentation of streams and reservoirs and environmental degradation from sediment associated pollutants.

In summary, the traditional approach to storm water drainage has been characterized by an excessive concern for convenience on-site, and by a lack of consideration for environmental and hydrologic effects on-site and downstream. Property damage, loss of amenity and recreational potential, stream deterioration, and high future costs to restore adequate channel capacity for flood protection can result.

2.3 Problems in Separate Sewer Areas

In fully-serviced urban areas where separate sewers have been constructed, the sanitary flow is conveyed directly to the sewage treatment plant via the sanitary sewers. In many areas, past or present design practice has led to the connection of weeping tile drainage to the sanitary sewer. In some cases flows from the roof-leaders have also been directed to the sanitary sewer. These practices can result in basement flooding and dilution of sewage strength, increased transmission and treatment costs, and reduced treatment efficiency, and are generally a misuse of the sanitary sewer system.

Restrictions on directing weeping tile and roof leader flows to the sanitary sewer have been satisfied in many areas by directing one or both flows to the storm drainage system via service connections. The storm drainage system, however, can become surcharged during severe storm events and this results in serious basement structural damage and flooding. Alternative disposal techniques for roof leader and weeping tile flows are provided in the "Manual of Practice on Urban Drainage" and briefly discussed in Section 4.2 of this report.

2.4 Problems in Combined Sewer Areas

In older areas with combined storm and sanitary sewers, one drainage network collects both sanitary and storm flows. Surface runoff occurs only as the result of precipitation or snow melt. In dry weather, only the "sanitary" component of flow enters the combined sewer and is conveyed to a sewage treatment plant. In wet weather, the combined sewer carries at least two to three times the dry weather flow to the sewage treatment plant. When the plant hydraulic capacity or the sewer system capacity is exceeded, a regulating structure usually exists in the combined sewer system to allow overflow of the excess directly to watercourses.

No combined sewers have been constructed in Ontario since 1956, and many systems which were combined prior to this have since been separated or partially separated.

In areas drained by combined sewers, basement flooding problems are often acute. In addition to the causes of flooding outlined in the previous section, a frequent contributing factor is an increase in impervious surfaces over the life of the development. This creates increased rates and volumes of runoff, which in turn lead to more frequent surcharge of the combined sewer and basement flooding.

The same process can occur in areas served by separate storm sewers. Even where the initial drainage design was adequate, runoff-related problems can be expected if development continues without comprehensive land-use and drainage controls.

Combined sewers were designed to overflow in wet weather to avoid flooding of private property and streets, and to protect downstream trunk sewers and sewage treatment plants from excessive peak flows. Under ideal

conditions, combined sewer systems would overflow only occasionally. In reality, few combined sewer systems resemble the ideal. Even where the original construction was based on sound design principles, subsequent changes in land-use and sewerage have often altered runoff characteristics and sewer system performance, with a resultant increase in overflows. Local flooding problems are frequently tackled piece-meal, usually by increasing overflows from the sewer system to relieve surcharge conditions.

The volume, frequency and duration of combined sewer overflows are specific to each system, and can be greatly affected by the way a sewerage system is operated and maintained. Overflows contain a mixture of surface runoff, raw sewage, and the solids accumulated in the sewers during dry weather and scoured out by the much higher wet weather flows. These discharges contribute to both background pollution and shock loads in the receiver in wet weather.

Whenever a significant portion of the serviced area in a municipality is drained by combined sewers, the sewage received at the treatment plant during extended wet-weather periods or snowmelt will be diluted by inflow from surface runoff. In some areas, both combined and sanitary sewers are also subject to gross infiltration. Both inflow and infiltration can cause extended periods of high flows and reduced efficiency at sewage treatment plants. This problem is potentially more acute where advanced treatment processes are required, since such processes are less able to handle fluctuations in waste strength or flow rate. To protect sewage treatment plant efficiency, some or all of the excess flows are usually by-passed directly to receiving waters.

Many municipalities contain both older areas drained by combined sewers, and newer areas drained by separated sewers, reflecting design practice at the time of the original construction. Some sewer systems originally constructed as separated have been altered by intentional and wide-spread cross-connections that allow large volumes of storm-flows to enter the sanitary system. In addition, piece-meal or unsystematic sewer separation programs, and the construction of relief sewers may have been carried out in an effort to alleviate local flooding. It is difficult to clearly categorize the extremely complex sewerage system that can result. Determining the actual routing of flow, and predicting the magnitude and

frequency of surcharge or overflows in these systems may require the use of sophisticated simulation models.

2.5 Institutional Problems

Various provincial ministries and their agencies can exercise control over different aspects of urban drainage, runoff quantity and quality, watershed planning and land-use management. The various levels of municipal government also have jurisdiction over drainage matters and land-use planning. Usually, drainage works are installed in accordance with detailed engineering codes and criteria largely under municipal control.

Since each agency has a different jurisdiction and a mandate with a different emphasis, there is a potential for overlap, conflicts and gaps in the application to drainage design. Overlaps can lead to time-consuming redundant reviews of the same information. Conflicts are not necessarily unproductive, but may simply be a result of competing demands for land use, and money resources. The problem occurs when decisions are made by planners, designers or reviewing agencies within the narrow context of their mandates without consideration of possibly important factors extraneous to a specific decision. Gaps occur where no mandate is specifically assigned or where data or technical deficiencies have limited the ability of the designer or review agency to fill the gap.

There is a need for all concerned in drainage matters to develop a broader and more flexible outlook. At present, innovation tends to be stifled by the delays which can occur as a new idea is going through multiple approvals, and by narrow definitions of funding eligibility and acceptable practice.

3 NEED FOR A NEW APPROACH TO URBAN DRAINAGE

Current approaches to urban drainage have been identified as deficient or ineffective in solving the problems described in Section 2. Attempts to intensify or extrapolate present approaches to solve these problems will result in inappropriate expenditures. Specifically, continuation or extension of current methods for the design of storm drainage will lead to:

- direction of capital funds to drainage projects that increase convenience with limited assurance of property protection against damage from severe storms;
- investment in alterations (e.g., channelization or diversions) to watercourses to augment storm water drainage from new developments and prevent large-scale channel erosion without concern for downstream effects and fish habitats;
- increased downstream flooding;
- possible liability claims against municipalities on the basis of negligence for ignoring modern drainage design concepts;
- continued investment in combined sewer separation (without examining alternative approaches) often with little assurance that effective abatement of flooding or pollution will be achieved;
- channel sedimentation and erosion because of unnecessary soil loss from construction sites;
- loss of aesthetic features and recreational uses of many streams and watercourses;
- continuing water quality degradation caused by flows from storm sewers, combined sewer overflows and sewage treatment plant by-passes during and after wet weather;
- increasing expenditures for controlling pollution at sewage treatment plants when improvements in water quality might be achieved more cost-effectively by dealing with the diffuse sources of pollutants carried in urban storm drainage.

The current framework for planning and designing new sanitary services and sewerage systems is satisfactory. However, improved and more

comprehensive storm water drainage planning and design procedures are needed. Comprehensive guidance for proper planning and application of the best available analytical techniques and drainage practices has not been provided. This report proposes policies that make provision for the development of proper guidance through better coordination between the various government agencies involved, and simplified urban drainage servicing administrative and approval procedures.

4 PLANNING APPROACH TO URBAN DRAINAGE

4.1 Introduction

The proposed approach to urban drainage management applies new and existing urban drainage concepts through a broader use of existing planning mechanisms, and introduces innovative technology where needed. New concepts have been described in detail in previous publications* and are summarized in this section. The incorporation of urban drainage concepts and principles into land use, environmental and flood control planning are discussed, and new technologies for analysing, measuring and controlling runoff quality and quantity are described.

4.2 New Concepts for Urban Drainage

Proper planning of urban drainage systems must consider the use of the natural drainage system with the goal of retention of the pre-development runoff hydrograph. Other important concepts for urban drainage include the use of the watershed as the logical unit for drainage planning, the recognition of the dual role of the major and minor drainage systems, and recognition of the necessity for cost-effectiveness in drainage and environmental planning. The existing framework for land use, environmental and drainage planning can be used to apply these concepts.

4.2.1 The natural drainage system

Urban development and the associated drainage systems can drastically alter the natural hydrologic regime in the area developed and in the watercourse downstream of the development. Consideration should be given to maintaining the natural pre-development hydrologic conditions where possible and beneficial. This includes provisions for groundwater recharge and maintenance of water tables, runoff volumes and rates and baseflows in dry periods. Higher density developments may preclude achievement of some aspects of this goal since opportunities for mitigating works may be reduced; however, where attainable at reasonable cost, the principle of natural drainage should be adopted.

The retention of pervious surfaces in new developments can help to maintain the existing hydrological conditions. Where practical,

* Manual of Practice for Urban Drainage, COA Research Report No. 104; Modern Concepts in Urban Drainage, COA Conference Proceedings No. 5.

decreases in the perviousness of the developed area, which would reduce the infiltration and interception capacity of the land, should be minimized. Draining impervious areas to adjacent pervious areas, e.g., discharging rooftop drains to grassed areas, is one technique that offsets the loss of pervious areas.

The adverse effect of development on the hydrologic response can be remedied in some instances by the provision of storage facilities for excess drainage flows. Permanent or temporary ponds can reduce peak runoff, aid in groundwater recharge, provide a facility for the treatment of storm water runoff, and lessen downstream flooding, erosion and sedimentation. Roof tops, parking lots, fields, swales, parks, road embankments, pits, ponds, reservoirs and storm sewer conduits can provide storage capacities for storm water runoff. Where the storage of storm water in ponds is practicable, releases from the ponds should simulate the pre-development hydrograph for more frequent storms, or be guided by downstream limitations.

Natural watercourses should be maintained and used whenever possible to convey storm water runoff. Rechannelizing, straightening, lining and enclosing the natural watercourse should be avoided whenever possible, as this usually causes larger downstream peak flows and higher downstream drainage costs. Special attention must be paid to the design of storm sewer outfalls to natural watercourses so as to ensure that they blend into the environment and cause no erosion problems. For open watercourses which form part of the major system, the extent of the flood plain must be defined according to the criteria recommended by the Ministry of Natural Resources. Land-use controls must be exercised within the designated flood plain.

The degree to which the natural drainage system concept should be or can be applied depends on the conditions of the local watercourse, as established in watershed planning described below.

4.2.2 Using the watershed as the logical unit for drainage and environmental planning

Urban runoff systems compete for space and resources with other land and water uses. To protect the designated function of a parcel of land, and to minimize downstream flood and environmental damages, urban

runoff system design should be carried out at the earliest practical stage of development. Drainage designs should be based on, and support, a master drainage plan for the entire watershed. Master plans for storm drainage should be developed and maintained at all times for each drainage basin. The planning for drainage facilities should be coordinated with planning for open space, planning for sanitary sewage disposal, and planning for transportation. By coordinating these efforts, new opportunities may be identified which can assist in the prevention of drainage problems.

The natural boundary for water resources planning is the watershed, which acts as a single, integrated system during runoff events. Consequently, flood control is best carried out on a watershed basis. Conservation authorities in Ontario are typically defined by watershed boundaries for flood control planning and operation of flood control systems.

Environmental planning is also best carried out on a watershed basis since watercourses act as a natural disposal system for the conveyance and assimilation of sewage runoff from all land uses in the watershed.

Master drainage plans, which are usually based on municipal or development areas, are the best method of incorporating watershed principles into land development planning. The master drainage plan must identify demands and problems within the watershed, establish watershed management objectives, and analyse alternative strategies to achieve the objectives.

Consideration should be given to the effect of development on environmental quality and hydrologic responses such as runoff peaks and volumes, base flows and groundwater recharge.

4.2.3 Concept of the major and minor drainage systems

A storm water runoff system is composed of both natural and man-made elements. The entire system consists of not only those components that contain and convey storm water but also those that absorb, store and otherwise use storm water rather than dispose of it. The storm water system is a single system having two purposes:

- the control of storm water runoff to prevent or minimize damage to property and physical injury and loss of life that may occur during or after a very infrequent or unusual storm; and
- the control of storm water to minimize inconvenience or disruption of activity as a result of runoff from more frequently occurring but less intense storms.

These are often characterized as the major and minor functions, and the drainage system itself is broken down into major and minor system components.

The major system is the route followed by runoff waters when the capacity of the minor system is exceeded. It generally consists of roads and open channels. Additional property protection is provided by lot grading control to provide additional elevation between flooded roadways and structures. Where the natural drainage route does not follow the road network, easements to a watercourse or to other roads should be provided. Where no surface route is available, storage elements or conduits may be required to maintain the major system.

The entire drainage system should be designed to provide a level of protection of property and life that fulfills the first or major function. The minor system is intended to provide an appropriate level of convenience. "Level of convenience" is defined by the frequency of storms that would cause runoff that would exceed the minor system capacity, resulting in surface ponding and some inconvenience. The level of convenience selected depends on the use of the major system components and the need for maintaining service. In certain cases, e.g., where arterial roads and highways are major system elements, access must be provided for emergency vehicles even during infrequent storms. Any storm water drainage system subject to infrequent major storms cannot be expected to prevent all inconvenience and minor property damage. A design that would eliminate all such stress would be fundamentally unreasonable and almost certainly prohibitively expensive.

When the capacity of the minor system is exceeded, the minor system household connections must be protected to ensure that basement flooding and structural damage are avoided. Various methods are available to prevent basement flooding and structural damage caused by household

connections to sewers subject to surcharging. Most of the methods listed below have been used in Ontario:

- connection of tile drains to an outlet other than the storm sewer subject to surcharge (e.g., a sump pump, a third pipe functioning as foundation drain collector or, in exceptional cases, a sanitary sewer);
- surcharge protection of the connection by check valves and sump pumps;
- protection of the sewer from surcharge through inlet controls;
- disconnection of roof leader downspouts to reduce flow to storm sewers, thus reducing the likelihood of surcharge;
- grading of property so that the basement is above the maximum level to which water will rise in the system;
- elimination of basements in new developments where there is a high probability of flooding.

The choice of method depends on acceptability, restrictions on connections to sanitary sewers, cost, and environmental considerations. Connecting tile drains to sanitary sewers, although practised in many locations, can aggravate basement flooding and create serious problems at water pollution control plants. It is generally discouraged by the Ministry of the Environment.

4.2.4 Concept of cost-effectiveness and cost-benefit

Cost-benefit analysis should be applied in all drainage studies in order to achieve economic efficiency or cost-effectiveness. Cost-effectiveness is the achievement of the maximum possible benefit for a given investment.

Environmental benefits are difficult, if not impossible to quantify in dollars. Flood control benefits can be quantified in terms of damages controlled or offset; however, drainage designs have not used this procedure to date. In practice, economic analysis often reduces to a minimum the cost analyses performed for fixed benefits, either environmental objectives for a receiving water or at a discharge point, or for a level of protection assumed to be provided by the storm frequency used for storm sewer design. Usually, the scope of options open to the designer in this type of analysis is narrow and true least-cost designs are not always possible.

It is recommended that, whenever practical, the scope of the current least-cost analysis approach be expanded to include other costs and benefits of tangible or intangible nature. It is also important to consider as many additional options as possible for achieving project objectives, so that the optimum design can be determined. Such an expansion of the economic analysis is possible when studies are carried out on large units of land such as watersheds.

This concept is particularly useful when decisions for water pollution control must be taken in existing urban areas. Advantage can be taken of opportunities to consider the most cost-effective options only when the pollutant inputs from the entire urban area and the effects on the receiving watercourse are considered. For example, no expenditures should be made for tertiary treatment at sewage treatment plants without first determining whether greater pollutant load reductions could be made at less cost by controlling combined sewer discharges.

4.3 Planning

The various types and levels of planning offer many opportunities to incorporate urban drainage considerations when they are most cost-effective and easiest to achieve.

In this section, land-use planning, environmental planning and drainage planning mechanisms are described. Ideally, the concepts and principles described in the previous section should be incorporated into the planning process whenever applicable and feasible.

Although the three planning mechanisms are interrelated, they have been carried out somewhat in isolation in the past. By promoting their integration, no implication is intended that drainage planning or that environmental planning should dictate land use strategies; however, land use planning should include drainage and environmental considerations.

4.3.1 Land use planning

Any increase in the intensity of land use or change in the activities on land usually results in higher rates and volumes of runoff and poorer water quality. While the environmental quality effects can be reasonably regulated through available legislation at the provincial level, more effective results can be achieved by incorporating urban

drainage design considerations earlier in the planning process at the municipal level.

The watershed characteristics, stream limitations and the natural features and constraints of the site should be considered early in land use and urban planning. A more cost-effective and environmentally sound urban drainage system design should result than can be achieved when land use and drainage system planning are performed independently.

It has been concluded that there is no need to develop new or revised legislation. Existing statutes cover planning and development, municipal authority, water management and environmental quality. Appendix II provides a summary of the pertinent legislation. A number of areas of overlap occur in this grouping of legislation and the situation may appear complex. However, optimal solutions for urban drainage can be achieved through a better understanding of urban drainage management and land use planning and greater cooperation between the various participants. The concepts and environmental constraints of storm water management must be considered throughout the planning and development process in addition to pollution control.

The Planning Act provides the statutory framework for land use planning and implementation at the local (municipal) level. The Act is administered by the Ministry of Housing and the Ontario Municipal Board with part of the administrative authority delegated to the regional municipalities. The key responsibilities are the review and approval of official plans and amendments, subdivision plans, and restricted area or zoning by-laws, and the provision of advice to municipalities on planning matters. Many provincial agencies, including the Ministries of Environment and Natural Resources, have a significant involvement in the process since their advice is solicited on planning and development proposals and documents. Municipalities and the concerned provincial agencies should ensure that adequate consideration of the control of urban drainage is provided for in the land use control process at the time of the review.

4.3.2 Environmental planning

Urban drainage related pollution problems in existing developed areas and in new developments originate from surface runoff, combined sewer overflows, sewage treatment plant effluents and by-passes. In

planning for environmental control, it is desirable to consider all sources of pollutants that significantly affect the quality and intended use of the receiving waters. Water quality problems in receiving waters for urban areas are the result of pollutant loadings from a wide variety of dry and wet weather sources. However, until recently consideration was given only to the control of continuous discharges of pollutants from treatment plants to meet receiving water quality objectives under dry weather conditions.

In Ontario the overall goal of surface water quality management is to ensure that the surface waters of the province are of a quality that is satisfactory for aquatic life and recreation. It is assumed that water meeting the quality criteria for aquatic life and recreation (designated the Provincial Water Quality Objectives*) will be suitable for most other beneficial uses.

The rationale for controlling a particular pollutant on an across-the-board basis or for requiring a minimum level of treatment or control would be that the pollutant or combination of pollutants are highly toxic or pathogenic, or would build up in the environment, or would have an adverse effect in the ultimate receiving body of water. Following this logic, the use of certain pesticides, DDT for example, has been curtailed. In addition, a minimum level of secondary treatment is required for secondary sanitary discharges to all receiving waters except in certain areas in the upper Great Lakes and their interconnecting channels, and St. Lawrence and the Ottawa Rivers, where adequate dilution capacity is available to avoid significant impairment to downstream waters. In these cases, a minimum level of primary treatment is required. Phosphorus discharges from point sources are controlled because of eutrophication in the Great Lakes, the ultimate receiving water body for most of Ontario's developed areas. The International Joint Commission, Pollution from Land Use Activities Referen Group is recommending further control of both point and non-point sources because of predicted continuing degradation of the lower Great Lakes, especially on the basis of continued phosphorus discharges.

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*Water Management - Goals, Policies, Objectives and Implementation Procedures of the Ministry of Environment, Ontario, November, 1978.

In 1978 the Governments of Canada and the United States reviewed the progress made under the 1972 Agreement on Great Lakes Water Quality, and signed a new agreement* in which they tentatively assented to new target loads for phosphorus discharges to the Great Lakes. The Phosphorus Management Strategies Task Force was established by the IJC's Science Advisory Board to, among other things, review the available technologies to reduce both point and non-point source inputs and to recommend a staged phosphorus management strategy. In their report** to the IJC it was noted that total phosphorus loads from urban non-point sources were not large in view of the relatively small area involved (5% of the land drainage area of the Great Lakes); however, loads on a unit area basis were comparable to those from some agricultural areas. More important perhaps, it was noted that heavy metal loadings from urban areas exceeded background levels from agricultural lands. Thus, remedial programs implemented in urban areas could include provisions to reduce metal as well as phosphorus loadings.

In addition to assisting in the development of target loads for the Great Lakes, Ontario carries out waste assimilation studies with individual municipalities to establish levels of dry weather effluent treatment that will enable compliance with water quality objectives in local receiving waters. Comprehensive studies of entire watersheds have been carried out only where problems were severe, complex and interrelated, and proposed solutions conflicted. Complex studies, which require a special effort because of unique problems and circumstances, have been carried out in the Grand River and Thames River.

Community wastes (sanitary and industrial) are a continuous and major potential pollutant source in urban areas. Efficient collection and treatment of community wastes is an essential factor in arresting or reversing water quality degradation and reducing hazards to human health. Since community wastes are relatively easy to collect and control compared to other more diffuse or intermittent sources of pollution, municipal

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* Phosphorus Management for the Great Lakes, final report of the Phosphorus Management Strategies Task Force, International Joint Commission, Windsor Ontario, July 1978.

**Lakes Water Quality Agreement between the United States and Canada, signed at Ottawa, November 22, 1978. Windsor, Ontario, 1978.

water pollution control programs in urban areas of Ontario have emphasized the collection, transmission and treatment of this sewage.

New sewage collection systems have been constructed as separated storm and sanitary systems since 1956, and municipalities have been encouraged to separate existing combined systems in an effort to further improve the efficiency of collection and treatment of sewage. It is now becoming clear that options other than separation are not only possible, but sometimes even more effective and less costly, for reducing both pollution and flooding problems.

When control has been achieved over the dry weather loadings from sewage treatment plants, it has become apparent that wet weather sources and other diffuse sources can contribute significant loadings and have a severe impact on water quality. To enable continued urbanization, maintain acceptable water quality, and remedy existing problems, environmental planning must take into account wet as well as dry weather sources of pollution. Watershed planning, with a pollution control strategy for each municipality based on all sources of pollutants, is the most comprehensive strategy available.

4.3.3 Drainage planning

Drainage planning and design is normally carried out during the later part of land-use planning. As an area is developed, a sewer system is designed as part of the servicing for the development. Often only the area drained is considered in the design.

Drainage planning is carried out primarily by municipalities and conservation authorities. Municipalities provide drainage systems to drain public and private lands as part of the package of services provided to developed land within municipal boundaries. In two-tiered municipalities, generally the local municipality provides for storm drainage while the regional municipality provides sanitary trunk drainage, or combined interceptor drainage in the case of a combined sewer system. (Sanitary sewer collectors may be either a local or regional municipality responsibility.)

In Ontario, conservation authorities are well established, professionally staffed, autonomous bodies organized on the basis of watershed boundaries. Their purposes are to plan, develop and operate

flood control, resource management, water conservation and recreation programs. They are supported by the municipalities in the watershed and by the Province on a cost-shared basis. Conservation authorities are particularly well-suited to play a major role in drainage planning because they have an overview of the entire watershed and they can play a coordinating role among the municipalities concerned.

Until recently, conservation authority jurisdiction over urban areas included water courses with drainage areas greater than 125 ha (one-half square mile) within which flood plains were required to be delineated and development curtailed on the flood plains. Recent modifications to this requirement allow for consideration of a two-zone floodway-flood fringe concept. Under this concept, development would be permitted on the fringe of a flood plain if special flood protection measures were adopted, while no development would be permitted in the main channel or floodway. Conservation authorities may delegate jurisdiction for urban storm water management in larger areas than indicated above, once a municipality has adopted a storm water management plan that complies with the objectives of flood plain management and master drainage planning.

4.4 Technology for the Analysis and Control of Urban Runoff

Technology relevant to the analysis and control of urban runoff falls into four main areas:

- characterization of flow and pollutant loadings in urban drainage systems;
- predicting receiving stream response;
- source controls (on runoff quantity or quality);
- collection, storage and treatment of runoff.

In each of the four areas, a substantial and impressive range of new technology has been developed in recent years, much of which is already being applied in Ontario, elsewhere in Canada and in the United States. Continuing research is expected to extend and improve technology, and added benefits will come from practical experience. In certain individual jurisdictions, some of these newer techniques and approaches not only have been tried out, but are already being fully implemented (for example, erosion-sediment control in the State of Maryland).

The available technology is well-documented and has been summarized in publications such as:

- Manual of Practice for Urban Drainage, COA Research Report No. 104, 1980.
- Urban Runoff Pollution Control Technology Overview, U.S. EPA 600/2-77-047, 1977.
- Area-Wide Assessment Procedures Manual, U.S. EPA 600/9-76-014, 1976.

While some gaps remain to be filled in present day technology, the body of existing knowledge seems more than adequate to permit implementation of the proposed urban drainage policies.

5 PROPOSED MODEL POLICIES FOR URBAN DRAINAGE

The five policy proposals detailed in this chapter can form the basis of a new approach for urban drainage management in Ontario. Adoption and implementation of the concepts inherent in the proposals will minimize existing drainage problems and prevent future drainage problems in a cost-effective manner.

The proposals are stated in terms applicable to the administrative framework in Ontario. While the statements are called "policies" throughout this chapter, it must be recognized that they are "proposals" unless and until adopted formally by the Province of Ontario.

5.1 Master Drainage Plan

Policy 1. Municipalities, in coordination with the conservation authorities or the provincial government, should develop master drainage plans.

a) The purpose of the master drainage plans is to ensure that storm water drainage systems will be developed in a manner compatible with watershed needs, that existing problems are properly identified, and that future potential drainage problems will be avoided. The effects of drainage proposals associated with developments can be most efficiently and speedily assessed if master drainage plans have already been prepared for the entire municipality, and especially for the receiving watercourse. For example, the specific requirements for subdivision drainage plans outlined in Policy 4 are more easily fulfilled if a master drainage plan is in place for the municipality.

b) While master drainage plans would be developed by municipalities and follow municipal boundaries, the watershed should be recognized as the logical natural unit for drainage planning. Where watershed boundaries cross municipal boundaries, inter-municipal coordination would be necessary to resolve drainage problems. Drainage plans should be formulated under the coordination of conservation authorities or, in the absence of local conservation authorities, under the coordination of the Ministries of Environment and Natural Resources.

c) It is the intent of this policy to foster master drainage planning for rapidly developing municipalities. Accordingly, municipalities should develop master drainage plans at the regional or local level within three years after implementation of the policy, taking into full consideration all planned and future development in the watershed. This policy should apply to all municipalities with a two-tiered structure and to municipalities designated by the Province of Ontario. Un-designated municipalities are encouraged to carry out master drainage planning.

d) The master drainage plan for a municipality should delineate watersheds, indicate the route of major and minor drainage systems for existing development, indicate areas and watersheds subject to development pressure, indicate drainage channels subject to erosion, designate drainage channels and associated valleys and floodplains with high recreational potential or unique natural characteristics, indicate potential groundwater recharge areas, and show any other factors deemed necessary and appropriate. The master drainage plan should indicate specific flood control and environmental objectives, including receiving water objectives and the measures that will be required to meet the objectives in planning developments and avoiding environmentally sensitive or hazardous areas.

e) Municipal 'official plans' should include a statement of policy objectives relating to storm water management and indicating the requirement for master drainage plans in developing areas. The master drainage plan should reflect the objectives stated in the official plan of the municipality. As an implementation tool for the official plan, the master drainage plan could indicate appropriate zoning for watercourses, floodplains and areas undergoing development, and stipulate requirements for drainage considerations at the various detailed planning levels where appropriate or necessary.

5.2 Pollution Control Strategy

Policy 2. Each municipality should formulate and implement a comprehensive pollution control strategy related to its own particular land-use, drainage and runoff characteristics.

a) The pollution control strategy is intended to define a combination of measures that will achieve the level of control over pollutant discharges from all sources necessary to meet receiving water objectives.

b) The strategy, once formulated, is intended to provide the basis for future water pollution control expenditures by the municipality, subject to periodic updating. To provide sufficient time for comprehensive analysis, at least two years should be allowed for data collection, developing loading estimates and receiving water impacts, and evaluating alternatives.

c) Preparation of the strategy should begin with a gross overall analysis to determine the relative magnitude and distribution of major water pollution problems in the municipality at present and in the foreseeable future, and an in-system review to indicate sewer system characteristics and wet and dry-weather sources of pollution. This preliminary analysis should rely on existing or readily available data, and should indicate those areas requiring detailed investigation and data collection programs.

d) The maximum allowable discharge loadings of critical pollutants should be established in conjunction with the Ministry of the Environment through master drainage planning and/or waste assimilation studies based on the Ontario Provincial Water Quality Objectives.

e) To ensure a comprehensive approach, loading effects and controllability of all significant pollution sources should be evaluated, including (as applicable) but not restricted to:

- sewage treatment plant effluent discharges;
- sanitary sewer by-passes (in the sewer system and at the sewage treatment plant);
- storm sewer discharges (including fugitive and illegal discharges);

- combined sewer overflows;
- industrial waste discharges;
- other non-point sources within the municipality.

f) The efficiency and effectiveness of current and proposed sewage treatment processes should be evaluated for both dry and wet-weather conditions. The effects of anticipated variations in influent quantity and quality, due to inflow-infiltration, or storm flows should be considered when evaluating wet-weather performance. Systematic analysis of wet-weather performance should be mandatory where advanced treatment is required and where the Ministry of Environment has determined that variations in waste strength and high hydraulic peak flows are adversely affecting existing treatment plant performance.

g) The effectiveness of other municipal practices and programs relevant to controlling pollutant discharges to sanitary or storm sewerage should be considered, including:

- enforcement of sewer use and industrial waste by-laws;
- sewer maintenance, operation and rehabilitation;
- street sweeping and solid waste collection.

Where existing practices are found ineffective, commitments to upgrade them should be incorporated in the pollution control strategy. Where new practices appear to be cost-effective, their inclusion in the strategy will be considered.

h) Major planned changes in land use or drainage practice (such as downtown redevelopment or sewer separation), which could significantly change the patterns of urban runoff, should also be systematically considered when developing or updating pollution control strategy.

i) Pollution control strategy should be developed with full awareness of the effects of various alternatives on flooding within the serviced area and downstream.

j) The formulated remedial and preventive programs, together with a schedule of implementation, should be incorporated into the

pollution control strategy which, when approved by the Ministry of the Environment, should be effective immediately for the municipality.

k) It is the intent of this policy to control pollution abatement expenditures in the most cost-effective manner. Accordingly, municipalities with significant existing pollution problems, as identified by the Ministry of the Environment, should carry out pollution control strategy development within three years after the implementation of the Urban Drainage Policy. The highest priority should be given to municipalities undergoing hydraulic expansion of sewage treatment facilities, particularly those where the Ministry of Environment has indicated a possible need to simultaneously upgrade the treatment process. The next priority should be given to municipalities where a significant proportion of the area or population is served by combined sewers. Developing municipalities where pollution problems are anticipated are encouraged to prepare a pollution control strategy as early as possible.

l) Municipalities within a two-tiered structure and municipalities transferring storm water or sewage to other municipalities for treatment or for disposal may be encouraged to enter into cooperative studies. The appropriate approach and coordination of the studies should be developed on a case-by-case basis between the municipalities involved and the MOE region.

Municipalities with treatment plants having a design capacity below 4546 m^3/d (1 Imgd) will generally be exempted from this policy until a design capacity above 4546 m^3/d (1 Imgd) is required. The Ministry of the Environment, at its discretion, may revoke this exemption for a specific municipality, and request that a pollution control strategy be developed.

Note on the Interrelationship between Policies 1 and 2:

Policy 1 (master drainage planning) deals largely with watercourses and requires primary consideration of the hydrological, water quality and channel erosion concerns in the watershed. The scope of planning would be broad with relatively little technical detail. The

result would be sets of specific objectives for sections of watercourses, indicating uses that must be maintained and providing a general identification of preventive or remedial measures required to meet these objectives. Such measures will then be consolidated in more detailed studies, such as the pollution control strategy required by Policy 2.

Policy 2 (pollution control strategy formulation) deals primarily with the sanitary, storm and combined sewer drainage areas of municipalities with communal collection and treatment systems. The water quality effects and cost of improving or maintaining water quality through control of sources within the municipality are emphasized. Effluent requirements would be set through a watershed plan such as described in Policy 1, or by a waste assimilation study which may form part of a watershed study, a pollution control strategy study or an independent study.

5.3 Major and Minor Drainage Design

Policy 3. Storm drainage systems for all development should be designed using a major-minor concept which recognizes the dual function of the drainage system of providing convenience, and protecting life and property.

a) In planning, designing and analysing storm drainage projects, a wide range of runoff conditions should be considered, including frequent runoff events and rare but severe runoff events that could cause substantial flooding. Storm drainage systems should be designed in accordance with, and accomodating, master drainage plans and pollution control strategy plans, if these are in place.

b) The major system* should provide protection against flooding equivalent to that provided by the flood plain criteria published by the Ministry of Natural Resources. The design runoff event frequency used to estimate runoff for major storm drainage facilities within a major-minor system, in the absence of design criteria determined by the Ministry of Natural Resources, should be the 1 in 100 years runoff event for all land uses to minimize flood damage.

*The major and minor systems are defined in Section 4.2.3 and the glossary in Appendix I.

c) The minor system* should be designed to avoid excessive costs incurred through the use of overly-conservative design techniques or excessively rare design storms for estimating runoff, bearing in mind that the major system will provide protection against damage from runoff events that exceed the capacity of the minor system. The minor system should be designed to provide the level of convenience appropriate for the area being drained. A design runoff event frequency of once in two years should be considered for low to medium density residential areas. For commercial and downtown business areas, a design runoff event frequency of up to 1 in 10 years should be considered.

d) The minor drainage system should be designed to be compatible with the major system, so that damage does not occur to property because of connections to surcharged storm sewers.

e) In developed areas or areas undergoing redevelopment where drainage systems have been constructed or designed without due consideration of the major-minor system concept, remedial measures to protect against flooding to the level as specified in (b) may be extremely expensive. Similarly, modification of existing under-sized minor systems to increase protection against flooding to the level as specified in (c) may also be very costly. In these situations, the levels of convenience and property protection provided would have to be determined by cost-benefit economic evaluations.

f) Whenever practical, drainage systems should be designed to take into account the projected future growth of the development and resulting changes in land-use. Where a specific future growth period has not been determined by a provincial or local government agency, the designed drainage system should ideally accomodate a 20-year growth.

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*The major and minor systems are defined in Section 4.2.3 and the glossary in Appendix I.

5.4 Subdivision Plan

Policy 4. The draft plan of subdivision for new developments should indicate the predicted effects of the proposed subdivision on water resources and the measures proposed to mitigate or prevent adverse effects.

a) The purpose of this policy is to provide for adequate assessment of the effects of proposed urban developments and redevelopments on water resources so that measures can be formulated and carried out to mitigate or prevent significant adverse impacts. The policy is best implemented in the context of a master drainage plan for the municipality, so that the overall interrelating and cumulative effects of individual developments within the municipality can be properly analysed. It is recognized that it may take a number of years to develop master drainage plans and that not all municipalities will be required to develop such plans. Accordingly, specific requirements for those developments which require subdivision approval by the Ministry of Housing are outlined below. Developments not subject to this review are encouraged to perform the same assessment and in future may be required to do so by a master drainage plan.

b) One year after implementation of the Urban Drainage Policy, draft plans of subdivision should include with the submission an indication of the effects of the proposed subdivision on water resources and the measures suggested to mitigate effects, a sediment and erosion control plan, and an indication of the adequacy of the major and minor drainage systems incorporated in the design. Details of the major and minor drainage system requirements are described in Policy 3, and the sediment and erosion control plan is described in Policy 5.

c) To describe the effects of the subdivision development on water resources, the submission should include:

- the expected change in the runoff hydrograph from predevelopment conditions for both frequent and infrequent storms.
- the anticipated effects of the altered hydrograph on the receiving watercourse, e.g., channel erosion and flooding.

The reviewing agencies may request information in addition to the above requirements if the new development would affect an environmentally sensitive area. This information may include but is not limited to:

- the estimated reduction in groundwater infiltration, groundwater levels, and low flows in streams.
- the quantities of pollutant materials that will be conveyed in the runoff compared to predevelopment conditions, and the effect on the receiving watercourse and the quality of groundwater.

d) The submission should indicate either that the effects on water resources will be negligible, or will be rendered negligible or offset by mitigative measures. This may be fulfilled by indicating compliance with local drainage and environmental requirements, which may be stated in the master drainage plan if one exists or specified by the reviewing agencies.

e) The submission should be reviewed by appropriate agencies coordinated by the Ministry of Housing. This policy should not apply to subdivisions of less than six housing units or subdivisions with housing lots of greater than 0.5 ha. It should apply to all commercial, industrial, and institutional subdivision developments of greater than 0.5 ha.

Note on Policy 4

It is not the intent of this policy to impose on onerous burden or overly lengthy study requirements on developers of small subdivisions. It is felt that a suitable level of detail for submissions can be identified to satisfy the concerns of the small developer and provide the technical input necessary to accomplish the intent of this policy. As noted in 5.4 a), the policy is more easily implemented after a master drainage plan is in place; however, it is also the opinion of the Policy Committee that the controls described are both necessary and beneficial, and can be implemented without master drainage plans.

5.5 Sediment and Erosion Control

Policy 5. Erosion and sediment control measures shall be used in the planning and construction of urban developments to minimize soil loss and downstream environmental damages.

a) Erosion and sediment control should be exercised during all major land disturbing activities.* As required by Policy 4 b), an erosion and sediment control plan should be included in the submission for approval of the draft plan of subdivision.

b) The erosion and sediment control plan should provide an evaluation of construction activities impacting on water resources and the proposed mitigative measures. The Ministry of the Environment has published a handbook to assist in the preparation of the control plan**.

c) Erosion and sediment control plans should be evaluated by the appropriate government agencies on a site-specific basis in terms of the five principles outlined below. Since not all of these will be relevant to each site, the erosion-sediment control plan submission should include principles selected to provide the best combination of erosion and sediment control practices for the development. The five basic principles that will ensure minimal soil loss and reduce downstream environmental effects are:

- The development should be planned to fit the particular site, i.e., proper use of land and its topography.
- The smallest possible area of land should be exposed to erosion for shortest possible time.
- Erosion control practices should be used to prevent on-site damage.
- Sediment control practices should be used to prevent off-site damage.

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* Land disturbing activity refers to clearing and excavating, and transporting, filling (including hydraulic filling), or stockpiling earth.

**Handbook for Evaluating Construction Activities Impacting on Water Resources, Water Resources Branch, Ministry of the Environment, January, 1976.

- Control devices should be adequately maintained to ensure proper operation during and after construction, until the disturbed land is completely restored and the permanent ground cover (e.g., vegetation) is established.

d) The responsibility for follow-up maintenance of control works should be clearly established in the sediment and erosion control plan. This is especially important if the property on which the control works are situated will change ownership after construction and before permanent groundcover is established.

6 IMPLEMENTATION OF PROPOSED POLICIES IN ONTARIO

The development of a detailed implementation package and an assessment of the effects of the policies was beyond the mandate of the Policy Committee. This must await formation of an Urban Drainage Policy Implementation Committee. A brief outline of the likely method of implementation and the areas to be addressed by the Implementation Committee are presented in this section.

Similarly, specific references in Chapter 5 to timing, size of development, size of treatment plant, frequency of occurrence of runoff events, and information to be included in submissions should be considered tentative proposals only, subject to modification by the Implementation Committee during its finalization of the implementation package.

6.1 Administration of Policies

Master drainage plans, as proposed in policy 1, would be developed by a local agency, either a municipality or a conservation authority. The local agency in each municipality would either be designated by the province or determined by negotiation and cooperative agreements between local agencies. The mechanism for designating the local agenciy will be established by the Implementation Committee. Technical review and approval of the resultant watershed plans would be carried out by the Ministry of Environment and Ministry of Natural Resources.

Policy 2, dealing with the development of a municipal pollution control strategy, would be carried out by municipalities, with technical advice and review provided by the Ministry of the Environment. Resources and manpower will be needed by the municipalities in the development of their pollution control strategies. The available resources should be directed on a priority basis to those cases where the potential benefits are greatest. In general, the highest priority should be given to municipalities undergoing hydraulic expansion of sewage treatment facilities, particularly those municipalities in which the Ministry of the Environment has indicated the possible need to simultaneously upgrade the treatment process. Development of a pollution control strategy by a municipality in this priority category should ideally be completed before any formal application to the Ministry of the Environment for approval of

further hydraulic expansion of the sewage treatment plant(s) within the municipality. However, those municipalities expecting to seek such approval(s) within two years from the effective implementation date of this policy may request some relaxation of the full requirements. Applications for relaxation should then be considered on a case-by-case basis by the appropriate MOE regional office. The next level of priority should be given to municipalities with 25 percent or more of the serviced area or serviced population on combined sewers. In these municipalities, development of strategy should be carried out within three years of the implementation date of the Urban Drainage Policy.

Policy 3, which requires consideration of the major and minor drainage system in design, would be carried out by the proponent of the drainage works, either the municipality or the developer. Technical review would likely be provided by the Ministry of the Environment or the Ministry of Transportation and Communications, depending on whether the proposed design comes under the Ontario Water Resources Act or the Public Transportation and Highway Improvement Act. The relation of this policy to the flood plain criteria established by the Ministry of Natural Resources will have to be clarified by the Implementation Committee.

Policy 4, dealing with requirements for proposed subdivisions, should be carried out using the established procedure for review of draft plans of subdivision under the Planning Act administered by the Ministry of Housing.

Control of erosion and sedimentation resulting from land disturbing activities as required by policy 5 should be handled by local government. An effective program will require proper inspection to ensure the control measures are carried out. The relevant provincial government ministries should assist municipalities in planning and implementing effective erosion and sedimentation controls.

It is apparent that adequate planning procedures are available for implementation of urban drainage policies and that legislation is in place to support the policies. Perhaps more coordination among agencies would be required so that the environmental, drainage servicing, flood control and land use planning aspects of a development could be considered together and a proper balance achieved between the possibly conflicting

aspects of each. To this end and to ensure speedy processing of submissions, it is recommended that present plan approval procedures be integrated and the responsibilities of the various reviewing agencies be clarified in detail.

6.2 Technical Guidelines and Criteria Development

Packages of computer models for the analysis of runoff systems and comparison of various drainage, storage and treatment alternatives are available. Consequently, it was concluded by the Policy Committee that technologies are in place to allow the policies to be implemented. Although certain municipalities in Ontario are already using these analytical and control technologies to resolve drainage and pollution problems, they are applying the techniques in isolation. With the implementation of the proposed policies, the application of these innovative technologies will be promoted across the province. However, some gaps still exist in technology and further research is required.

Technical guidelines and evaluation criteria will be needed to implement the proposed policies. These guidelines and criteria would provide advice to proponents carrying out the required studies and applying for approvals, and help reviewers in government agencies evaluate proposals. To simplify the approval process and minimize delays in development, the respective reviewing agencies should jointly prepare and agree on the technical guidelines and evaluation criteria. It is recommended that the guidelines and criteria be issued as interim documents and modified periodically in light of experiences gained by the proponents and the reviewers.

A "code of practice" for municipal drainage works should be developed to standardize and simplify design. Acceptable design techniques, methods of analysis for precipitation, runoff and pollutant loading, sewer pipe and appurtenance sizing, design of storage facilities and other drainage control devices, methods to protect basements against flooding and any other useful design consideration should be incorporated in the code. The "code of practice" should be developed by a committee consisting of representatives from the Ontario Municipal Engineers Association, the Consulting Engineers Association of Ontario, the urban development industry, drainage equipment manufacturers and provincial

ministries involved in municipal drainage, including the Ministries of the Environment, Natural Resources, Housing, Transportation and Communications, and Consumer and Commercial Relations. It should be reviewed and updated continuously to reflect the knowledge and the practical experience gained by the committee members as a result of implementation of the Urban Drainage Policy. The "code of practice" should be compatible with other relevant design standards such as the "Ontario Bridge Code" administered by the Ministry of Transportation and Communications, and the "Ontario Plumbing Code" administered by the Ministry of Consumer and Commercial Relations. The "Plumbing Code" regulates storm drainage connections on private property, and may need revision to minimize the risk of property damage due to surcharged connections.

6.3 Technology Transfer

To facilitate the policy implementation, a small core group of technical experts may be needed to help the municipalities, proponents and reviewing agencies become familiar with the application of new and innovative analytical, design and control technologies. Research publications, technical bulletins, seminars and workshops should be directed to engineers, designers and planners working in the field of municipal engineering and pollution control. Additional technical material in support of individual policies or relating to the general areas covered by individual policies will also be needed.

Educational materials relating to the Urban Drainage Policy that can be readily understood by laymen and the general public also seems desirable, especially since many decisions at the municipal level rest with elected officials who may not be technical specialists.

6.4 Funding

A review of the existing funding programs indicates that eligibility for subsidy of most drainage works is based on conventional concepts such as piped storm sewer systems, dam construction or channel improvement for flood control. Many of the innovative concepts advocated in this report and in the "Manual of Practice for Urban Drainage" may not qualify for funding. The Policy Committee has recommended that major funding agencies proceed to revise the eligibility criteria to include the construction of these innovative storm water management measures.

The "Road Grants Program", administered by the Ministry of Transportation and Communications, partially funds the reconstruction of combined and storm sewers according to the Ministry's eligibility criteria. These eligibility criteria may need review to ensure compatibility with proposed policies.

Other funding sources such as the Department of Regional Economic Expansion (DREE), and the Community Services Contribution program also subsidize the construction of drainage systems, although to a small extent. The funding eligibility criteria of these programs should also be reviewed. Special subsidies or grants to encourage the development of master drainage plans and comprehensive pollution control strategy plans should be considered by funding agencies.

APPENDIX I

GLOSSARY OF TECHNICAL TERMS

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Advanced Treatment - process or method for supplementary treatment of sewage and other wastes beyond the quality achieved by conventional secondary treatment.

Combined Sewer - a sewer intended to carry surface runoff, sewage and industrial wastes allowed by sewer by-laws.

Convenience - the condition of availability or accessibility of a facility, such as roadway, for its intended purpose without nuisance or unfavorable conditions, such as would be caused by flooding. A "level of convenience" refers to the frequency of occurrence of nuisance conditions, such as would result from a storm with a known frequency of occurrence.

Cost-effective - answering the purpose of providing the optimum effect at the most reasonable cost.

Design Storm - a rainfall of specified amount, intensity, duration, pattern over time, and frequency as a design basis.

Dry Weather Flow - combination of domestic sewage and industrial and commercial wastes found in sanitary sewers during the dry weather season of the year.

Flood Plain - the area of ground along a stream course that is covered by water at flood stage.

Foundation Drain - a pipe or series of pipes that collects water drained from the foundation or footing of structures and discharges these waters into sanitary, combined or storm sewers or to other points of disposal, for the purpose of draining unwanted waters away from such structures.

Erosion - the process by which the ground surface is worn away by the action of wind and water; also the process by which the bed and banks of a stream are worn away by the action of water.

Eutrophication - the progressive enrichment of surface waters, particularly non-flowing bodies of water such as lakes and ponds, with dissolved nutrients, such as phosphorus and nitrogen compounds, which accelerate the growth of algae and higher forms of plant life and result in the utilization of the usable oxygen content of the waters at the expense of other aquatic life forms.

Groundwater Table - the free surface level of groundwater, subject to atmospheric pressure under the ground, generally rising and falling with the season, the rate of withdrawal, the rate of recharge, and other conditions.

Hydrograph - a flow versus time graph derived from direct measurement or prediction of runoff, or stream flow.

Hydrologic Cycle - the circuit of water movement from the atmosphere to the earth and return to the atmosphere through various stages of processes such as precipitation, interception, runoff, infiltration, percolation, storage, evaporation, and transpiration.

Impervious - not permitting penetration or passage of water.

Infiltration - the passage of water into the soil. The term is also used to refer to water entering a sewer system from the ground through such means as, but not limited to, defective pipes, pipe joints, connections and manhole walls, and including that from sewer service connections. It includes all extraneous water during wet weather, such as groundwater and surface water, but does not include inflow.

Inflow - the water discharged into a sewer system, including that from service connections, from such sources as, but not limited to, roof leaders, cellar, yard and area drains, foundation drains, cooling water discharges, drains from springs and swampy areas, manhole covers, cross connections from storm sewers and combined sewers, catch basins, surface runoff, street wash waters, and drainage. It does not include infiltration.

Major System - the route followed by storm runoff when the minor system is either inoperative or inadequate. It generally should consist of roads and major drainage channels.

Minor System - the drainage pipes, roadway gutters, enclosed conduits, and roof leader connections designed to convey runoff from frequent, less intense storms, to eliminate or minimize inconvenience in the area to be developed.

Pollutant - dredged soil, solid waste, incinerator residue, sewage, garbage, sludge, chemical wastes, biological materials, radioactive materials, heat, wrecked or discarded equipment, rock, sand, dirt and industrial, municipal and agricultural waste discharged into water.

Primary Treatment - processes or methods that serve as the first stage treatment of sewage and other wastes, intended to remove suspended and settleable solids by gravity and sedimentation. It provides no changes in dissolved and collodial matter in the sewage or waste flow.

Rational Method - means of computing storm drainage flow rates using the formula Q = CIA, where C is a coefficient describing the proportion of rainfall expected to run off based on the physical characteristics of the drainage area, I is the rainfall intensity, and A is the area.

Roof Leader - a drain or pipe that conducts storm water from the roof of a structure, downward and into a sewer for removal from the property, or onto or into the ground for disposal by seepage.

Runoff - that portion of the precipitation on a drainage area that is discharged from the area into stream channels.

Sanitary Sewer - a sewer that carries sewage and those industrial wastes permitted by sewer use by-laws.

Secondary Treatment - processes or methods for the supplemental treatment of sewage and other wastes, usually following primary treatment, to effect additional improvement in the quality of the treated wastes by biological means of various types.

Sediment - soils or other surface materials transported by wind or water as a result of erosion.

Sedimentation - the process of subsidence and deposition of suspended matter carried by water, sewage, or other liquids, by gravity.

Simulation - representation of physical systems and phenomena by mathematical models.

Storm sewer - a sewer that carries storm water and surface water, street wash and other wash waters or drainage, but excludes sewage and industrial wastes.

Surcharge - the flow condition occurring in closed conduits when the sewer is pressurized or the hydraulic grade line is above the crown of the sewer.

Urban Drainage or Urban Drainage System - includes both man-made and natural elements. An urban drainage network consists of two systems: sanitary and storm sewers.

Urban Runoff - Surface runoff from an urban drainage area that reaches a stream or other body of water or a sewer.

Watershed - the region drained by or contributing water to a stream, lake, or other body of water.

Water Table - the upper level of the free groundwater in a zone of saturation, except when separated from an underlying groundwater by unsaturated material.

Wet Weather Flow - a combination of dry weather flows, infiltration and inflow which occurs as a result of rain and storms.

APPENDIX II

PROVINCE OF ONTARIO LEGISLATION

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PROVINCE OF ONTARIO LEGISLATION

The following is a summary of pertinent legislation affecting drainage in the Province of Ontario. Several aspects of Common Law - such as riparian rights - apply to drainage considerations unless specifically set aside by legislation.

1. The Environmental Protection Act is an act to provide for the protection and conservation of the natural environment. The act carries wide ranging powers to control any possible activity of man that might directly or indirectly injure the environment, since the definition provided for "contaminant" includes anything that might cause pollution. Under these provisions, urban runoff is defined as a contaminant. Under this legislation, the Ministry of the Environment can prohibit or regulate the discharge of any contaminant as long as it can be proven that the contaminant can impair water uses and cause damage to life and property.
2. The Ontario Water Resources Act is intended to protect the water resources of the Province of Ontario. In this act, the term "sewage" includes drainage, storm water, commercial and industrial wastes, and the term "sewage works" means any works for the collection, transmission, treatment and disposal of sewage. The approval of "sewage works" is required under the Act and a person or municipality can be ordered to establish, maintain, operate, improve, enlarge, repair, etc. any sewage works.
3. The Environmental Assessment Act is to provide for the protection, conservation and wise management in Ontario of the environment. The Act requires that an environmental assessment of proposed projects and activities be prepared by the proponent to consider in part the potential effects of the activities on the environment and the means by which the effects could reasonably be mitigated. In the first phase, the Act applies to provincial projects. The Act has been proclaimed for the private sector but will be applied by regulation on a case-by-case basis. The conservation authority projects came

under the Act by regulation September 1, 1977, and are subject to phased implementation. The municipal sector came under the Act in 1978.

4. The Conservation Authorities Act provides for the establishment of conservation authorities for the purpose of establishing and undertaking, in the area over which they are given jurisdiction, a program designed to further the conservation, restoration, development and management of natural resources other than gas, oil, coal and minerals. The focus of their activities is water management for flood control.

5. The Planning Act provides for the adoption of an "official plan" by a municipality that will identify programs and policies designed to secure the health, safety, convenience and welfare of the inhabitants. In consideration of physical, social and economic conditions, the official plan has a very wide scope that would include storm water management policies and programs. No public works shall be undertaken which do not conform to the official plan. The Act also provides for the development of land by plans of subdivision and in their review consideration is to be given to conservation of natural resources and flood control. The municipality may enter into subdivision agreements that specify restrictions affecting the drainage of the urban area. The Planning Act gives municipalities the right to pass by-laws to control the use of land and manner in which land is developed.

6. The Municipal Act contains a number of provisions respecting drainage. A municipality normally only has power to act within its boundary, unless restricted by another statutory authority. The Municipal Act enables councils of municipalities to enact by-laws which may relate to drainage and water control.

7. The Local Improvement Act permits a municipality to undertake a large variety of "works", and to assess those homeowners who directly benefit from a much larger share of the cost than would be the case if the works were financed out of the general funds of the municipality. Major drainage works and shore protection can be included. New, extended and improved works are covered by the Act, but the simple

maintenance of existing works is not. The works may be undertaken by council initiative or by a signed petition of a majority (over 50%) of the affected homowners. Works carried out under this Act place a burden on a municipality's borrowing capacity, as the municipality must provide financing.

8. The Drainage Act, administered by the Ontario Ministry of Agriculture and Food, provides for the construction, improvement, or maintenance of drainage works by municipalities. Grants may be made in respect of assessments made under the act upon land used for agricultural purposes.

9. The Lake and Rivers Improvement Act, administered by the Ministry of Natural Resources, ensures the suitability of the location and nature of improvements in lakes, rivers, streams and watercourses, including their efficient and safe maintenance and operation. Alterations to water courses, such as diversions, channelization or dams, require approval under this Act.

10. The Beds of Navigable Waters Act provides for Crown ownership of the beds of navigable waters unless an express grant has been made to the contrary.

11. The Fisheries Act (Canada), administered in Ontario jointly by Environment Canada and the Ontario Ministry of Natural Resources, provides for the protection of fisheries. Specifically, it prohibits the deposition of deleterious substances in water frequented by fish, and prohibits any undertaking that results in adverse effects on fish habitats.

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